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April 8, 1997

Mr. William F. Caton  
Secretary  
Federal Communications Commission  
1919 M. St., NW, Room 222  
Washington, D.C. 20554

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Federal Communications Commission  
Office of Secretary

RE: Ex Parte Presentation  
Universal Service: CC Docket No. 96-45  
Access Reform: CC Docket No. 96-262 \*

Dear Mr. Caton,

The attached documents are being submitted to the Federal-State Joint Board and their staff on Universal Service. The first of these documents provides an analysis of the relative efficacy of the Hatfield Model and the BCPM at meeting the set of criteria that define an effective proxy cost model. This analysis shows that the Hatfield Model would be the superior choice for use in determining universal service support costs, unbundled element costs, and carrier access and interconnection costs. The second document is an analysis of the voice and data transmission capabilities of different copper loops that had been requested by the FCC and State staffs.

Two copies of this Notice are being submitted to the Secretary of the FCC in accordance with Section 1.1206(a)(1) of the Commission's rules.

Sincerely,

*Richard N. Clarke /s/*

Richard N. Clarke

Attachments

cc:	Anthony Bush	Robert Loubé
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# **QUALITY OF VOICE AND DATA TRANSMISSION ACROSS COPPER LOOPS OF VARYING LENGTH**

## **I. Overview**

This paper demonstrates that the Hatfield Model's (HM's) current engineering specifications permit the transmission of high quality analog voice and data across all of its copper loops. Furthermore, for over 99% of the HM's copper loops, the transmission of basic rate ISDN (2B+D) is also feasible. In contrast, the BCPM model engineers its copper loops not only to carry the above services, but also to carry higher bit rate business or entertainment services such as DS1 or HDSL.

## **II. Introduction**

An important issue in designing a local telephone network is the quality of voice or data transmissions across its copper loops. It is well known that, all things being equal, the longer the copper loop, the more difficult it becomes to maintain the quality of voice or data transmission. The key issues then, are twofold. One, what should be the minimum universal service requirement for analog bandwidth or digital data capability of the supported network's copper loops? And, second, what are the engineering specifications for the network's copper loops that will meet this requirement? This paper deals briefly with the first of these two issues, but focuses on the second.

## **III. Transmission Design Requirements**

While certain customers of local telephone service have a need for high bandwidth services, these needs are generally not thought to be eligible for universal service support. As the Federal-State Joint Board indicated in its August 8, 1996 Recommended Decision in CC Docket No. 96-45 on Universal Service,

... we recommend that ... voice grade access to the public switched telephone network ... be designated for universal service support .... [Recommended Decision, ¶46]

While the Joint Board may have recommended support only for "voice grade access," this does not imply that data transmission over the supported network is infeasible. To the contrary, as the following discussion demonstrates, a network designed to provide voice grade access will also be capable of handling substantial data transmission throughputs. But, rather than deciding here exactly what the supported level of voice/data transmission quality should be, this paper will instead simply consider four

alternatives for transmission design. It will then describe the characteristics of the copper loop network that are necessary for the network to be capable of meeting the specified transmission quality.

These alternative transmission requirements with their voice/data throughput capabilities are:

- 1) Analog voice  
"... commercially acceptable quality for telephone communications is ... bandlimited to the range of frequencies...between 200 Hz and 3500 Hz."<sup>1</sup>  
Note that this range is limited both by the bandwidth of the loop and by the switch. In particular, digital switches are designed only to process signals between approximately 200 Hz and 3400 Hz in frequency.<sup>2</sup> This switch processing limit is imposed by bandpass filtering in the codecs that perform the analog to digital signal conversions. This same filtering is performed by digital loop carrier systems as well.
- 1) Analog data (28.8 kbps modem, ITU-T recommendation V.34,)  
Modems meeting this standard attempt to use the maximum bandwidth available over the loop.<sup>3</sup> These modems "probe" the communications channel at the beginning of each connection to determine its characteristics. They then dynamically adjust the modem's internal parameters to transmit a data signal at the maximum bit rate possible over the channel.<sup>4</sup>

It is not unusual for users of V.34 modems to see connect speeds of only 21.6, 24.0 or 26.4 kbps – even on short loops which transmit relatively high signal levels. On longer loops, including those with loading coils, V.34 modems can be very effective at finding the maximum amount of bandwidth available over the connection and the location of this bandwidth within the

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<sup>1</sup> *Engineering and Operations in the Bell System*, 2<sup>nd</sup> ed., AT&T Bell Laboratories, 1983 (hereafter, EOBS) Section 6.1.1, p.194

<sup>2</sup> See, Bellcore, *BOC Notes on the LEC Networks - 1994* (hereafter, BNLN), Section 7.8, Table 7-2, p.7-28.

<sup>3</sup> "Analog V.34 modems utilize nearly the full bandwidth of the present day phone system (actually, more than the 'rated' bandwidth)." "Curt's High Speed Modem Page," Internet: <http://www.teleport.com/~curt/modems.html>.

<sup>4</sup> See, Forney, G. David, Jr., Les Brown, M. Vedat Eyuboglu, John L. Moran, III, Motorola, Inc., "The V.34 High-Speed Modem Standard," *IEEE Communications Magazine*, (December 1996), pp. 28-33.

analog spectrum provided over the loop.<sup>5</sup> After testing current modems under such conditions, modem developers have concluded that a V.34 modem should be capable of maintaining 24 kbps of throughput.<sup>6</sup>

- 1) Digital Subscriber Line (DSL) for ISDN Basic Rate Access (160 kbps, bi-directional)  
DSL permits the bi-directional transmission of 2B+D ISDN channels (64 kbps B-channels, 16 kbps packet data D-channel).<sup>7</sup> While the 2B+D channels transmit only at a total of 144 kbps, an extra 16 kbps of throughput is needed to accommodate network overhead.<sup>8</sup>
- 1) DS1 or High Bit-Rate Digital Subscriber Line (HDSL)  
These services require at least 1.5 Mbps of throughput over two twisted copper pairs. (BNLN, Section 12.12.2, p.12-45).

#### **IV. Loop Engineering Specifications Necessary to Meet Given Transmission Requirements**

BNLN, Section 7.15 (pp.7-66 to 7-69) cites three different loop engineering designs and the services transmittable on each. They are as follows:

- a) Carrier Serving Area (CSA)  
This design restricts copper loop lengths to 12 kft that are nonloaded, use 24 or coarser gauge cable, and have no more than 2.5 kft of bridged tap length, with no single tap longer than 2.0 kft. This design supports analog voice, ISDN DSL, 56 kbps data and certain special services.
- b) Revised Resistance Design (RRD)  
This design specifies a maximum copper loop length of 18 kft (including bridged tap) for nonloaded loops. For these nonloaded loops of 18 kft or less, RRD supports ISDN DSL, in addition to traditional analog services.

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<sup>5</sup> Modem testing procedures include the use of several standard loop designs, some of which include extremely long loops with several sets of loading coils. See, Briere, Daniel. "Test underscores differences in modem throughput," *Network World*, (May 10, 1993), pp. 40-43. See also, "V.FAST Class Modems," *InfoWorld*, (July 11, 1994).

<sup>6</sup> "Experience indicates a rate of 28.8 kbps can be achieved over the majority of lines in North America, Europe, and Japan, and 24 kbps over practically all lines except for intercontinental links with ADPCM, where 16.8 of 19.2 kbps is often the practical limit." [Forney, et al., p.32]

<sup>7</sup> See, BNLN, Section 7.15.6, p.7-69, Section 12.2, p.12-5, and Section 12.9.1, p.12-31.

<sup>8</sup> See, BNLN, Section 12.9.1, p. 12-31.

c) Modified Long Route Design (MLRD)

Permits resistances of 1500 to 2800 ohms on full H88 loaded copper loops.<sup>9</sup> The placement of load coils on these loops causes signals above 3000 Hz in frequency to be attenuated.<sup>10</sup> While analog voice and modem services are supported over these loops, digital services are not.

The HM as currently specified at its default parameter values incorporates both RRD and MLRD. Copper loops under 18 kft are not loaded and are generally capable of supporting voice, V.34 analog data at 28.8 kbps and ISDN DSL at 160 kbps.<sup>11</sup> Copper loops beyond 18 kft are engineered according to MLRD. Because they are fitted with load coils, these loops will provide only about 3000 Hz of bandwidth (versus about 3200 to 3300 Hz on RRD or CSA loops). While this accommodates very reasonable voice quality and data transmission over a V.34 modem at 21.6 or 24 kbps, it does not permit the transmission of digital services. MLRD over 19 gauge cable can, however, transmit its signal out to 210 kft or 40 miles.<sup>12</sup>

## V. Conclusions

Thus, the conclusions of this paper are as follows:

- a) The HM model permits excellent voice quality on all its loops, and V.34 analog data of 21.6 kbps or better on all of its loops.
- b) On the HM loops less than 18 kft, ISDN DSL is also available. These constitute over 99% of all the loops engineered by the Hatfield Model.
- c) The engineering justification for the BCPM's requirement that no copper loop exceed 12 kft appears to be driven by its sponsors' desire to make these loops capable of carrying DS1 or HDSL high bit rate business or entertainment

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<sup>9</sup> H88 loaded loops have load coils with 88 millihenries of inductance placed at 6000 foot intervals.

<sup>10</sup> See, EOBS, pp. 333-335.

<sup>11</sup> See BNLN, Section 7.15.6, p.7-69, "Almost all loops designed to resistance design criteria, whether RRD or its predecessors, will transmit a DSL signal out to 18 kft.

See, also BNLN Section 12.2, p.12-5, "New digital signal processing techniques, such as those used in the ISDN Basic Rate Access DSL permit the deployment of 160 kbps signal on most nonloaded loops ( $\leq 1300$  ohms) without any conditioning."

And BNLN, Section 12.9, p.12-32, "The DSL system is intended to operate on nearly all unloaded loops 18 kft or less in length."

<sup>12</sup> See, EOBS, p. 338.

services. This goal is made clear because BNLN Table 7-11 on p. 7-68 specifies that these types of special services are the only ones provisionable on CSA loops, but may not be provisionable on RRD loops greater than 12 kft in length. In addition, the BCPM documentation states the following:

“The 12,000 foot breakpoint also facilitates the provisioning of services up to DS1.” (p. 7); and:

“Distribution plant ... [in the BCPM model] ... may utilize digital carrier when terminations are made at the DS1 signal level for a percentage of business lines.” (p. 11)

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